PB83-115600

National Air Pollutant Emission Estimates 1970-1981

(U.S.) Environmental Protection Agency
Research Triangle Park, NC

Sep 82

U.S. Department of Commerce
National Technical Information Service
NTIS

United States
Environmental Protection
Agency

Office of Air Quality
Planning and Standards
Research Triangle Park NC 27711

EPA-450/4-82-012
September 1982

Air

PB83-115600

EPA

National Air Pollutant Emission Estimates, 1970-1981

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA 22161

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO.	2.	3. RECIPIENT'S ACCESSION NO.
EPA-450/4-82-012		PB83 115600

4. TITLE AND SUBTITLE	5. REPORT DATE
National Air Pollutant Emission Estimates, 1970-1981	September 1982
	6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S)	8. PERFORMING ORGANIZATION REPORT NO.
Monitoring and Data Analysis Division	
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Environmental Protection Agency Office of Air, Noise and Radiation Office of Air Quality Planning and Standards Research Triangle Park, North Carolina 27711	10. PROGRAM ELEMENT NO.
	11. CONTRACT/GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS	13. TYPE OF REPORT AND PERIOD COVERED Final - 1970-1981
	14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

16. ABSTRACT

This report presents estimates of trends in nationwide air pollutant emissions for the five major pollutants: sulfur oxides, particulates, carbon monoxide, volatile organic compounds, and nitrogen oxides. Estimates are broken down according to major types of air pollutant sources. A short analysis of emission trends is given, along with a discussion of methods used to develop the data.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
trends, emissions, inventory, air pollutants, nationwide, sulfur oxides, carbon monoxide, particulates, volatile organic compounds, nitrogen oxides, controllable emissions, miscellaneous sources		

18. DISTRIBUTION STATEMENT	19. SECURITY CLASS *(This Report)*	21. NO. OF PAGES
Release unlimited	Unclassified	
	20. SECURITY CLASS *(This page)* Unclassified	22. PRICE

EPA Form 2220-1 (9-73)

EPA-450/4-82-012

National Air Pollutant Emission Estimates, 1970-1981

Monitoring and Data Analysis Division

U.S ENVIRONMENTAL PROTECTION AGENCY
Office of Air, Noise and Radiation
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711

September 1982

1a

This report is published by the U. S. Environmental Protection Agency to report information of general interest in the field of air pollution. Copies are available free of charge to Federal employees, current contrators and grantees, and nonprofit organizations - as supplies permit - from the Library Services Office (MD-35), U.S. Environmental Protection Agency, Research Triangle Park, North Carolina 27711; or, for a fee, from the National Technical Information Services, 5285 Port Royal Road, Springfield, Virginia 22161.

Publication No. EPA-450/4-82-012

CONTENTS

Section	Page
LIST OF TABLES	vii
1. SUMMARY	1
2. NATIONWIDE EMISSION TRENDS, 1970-1981	3
2.1 Particulates	3
2.2 Sulfur Oxides	3
2.3 Nitrogen Oxides	4
2.4 Volatile Organic Compounds	4
2.5 Carbon Monoxide	4
3. METHODS	21
3.1 Transportation	22
3.1.1 Motor Vehicles	22
3.1.2 Aircraft	22
3.1.3 Railroads	23
3.1.4 Vessels	23
3.1.5 Nonhighway Use of Motor Fuels	23
3.2 Fuel Combustion in Stationary Sources	23
3.2.1 Coal	23
3.2.2 Fuel Oil	23
3.2.3 Natural Gas	24
3.2.4 Other Fuels	24
3.3 Industrial Processes	24
3.4 Solid Waste Disposal	24
3.5 Miscellaneous Sources	25
3.5.1 Forest Fires	25
3.5.2 Agricultural Burning	25
3.5.3 Coal Refuse Burning	25
3.5.4 Structural Fires	25
3.5.5 Nonindustrial Organic Solvent Use	26

ABSTRACT

This report presents estimates of trends in nationwide air pollutant emissions for the five major pollutants: particulates, sulfur oxides, nitrogen oxides, volatile organic compounds, and carbon monoxide. Estimates are presented for each year from 1970 through 1981. Emission estimates are broken down according to major classifications of air pollution sources. A short analysis of trends is given, along with a discussion of methods used to develop the data.

Preceding page blank

CONTENTS (continued)

Page

4.ANALYSIS OF TRENDS. 27

4.1 Particulates. 27

4.2 Sulfur Oxides 30

4.3 Nitrogen Oxides 31

4.4 Volatile Organic Compounds. 31

4.5 Carbon Monoxide 32

5.REFERENCES. 34

TECHNICAL REPORT DATA AND ABSTRACT. 36

LIST OF TABLES

Table		Page
1.	Summary of National Emission Estimates.	2
2.	National Estimates of Particulate Emissions, 1970-1981.	5
3.	National Estimates of Sulfur Oxide Emissions, 1970-1981	6
4.	National Estimates of Nitrogen Oxide Emissions, 1970-1981	7
5.	National Estimates of Volatile Organic Compound Emissions, 1970-1981	8
6.	National Estimates of Carbon Monoxide Emissions, 1970-1981.	9
7.	Nitrogen Oxide Emissions from Highway Vehicles.	10
8.	Volatile Organic Compound Emissions from Highway Vehicles	11
9.	Carbon Monoxide Emissions from Highway Vehicles	12
10.	Particulate Emissions from Fuel Combustion.	13
11.	Sulfur Oxide Emissions from Fuel Combustion	14
12.	Nitrogen Oxide Emissions from Fuel Combustion	15
13.	Particulate Emissions from Industrial Processes	16
14.	Sulfur Oxide Emissions from Industrial Processes.	17
15.	Nitrogen Oxide Emissions from Industrial Processes.	18
16.	Volatile Organic Compound Emissions from Industrial Processes	19
17.	Carbon Monoxide Emissions from Industrial Processes	20
18.	Theoretical 1981 National Emission Estimates with 1970 Level of Control	28

NATIONAL AIR POLLUTANT EMISSION ESTIMATES

1970-1981

1. SUMMARY

The primary objectives of this publication are to provide current estimates of nationwide emissions of five major pollutants: particulate matter (PM), sulfur oxides (SO_2), nitrogen oxides (NO_x), volatile organic compounds (VOC), and carbon monoxide (CO). Estimates are presented for 1970 through 1981 as an indication of recent trends. These data entirely replace those published earler for 1970-1980 in EPA report National Air Pollutant Emission Estimates, 1940-1980 (EPA-450/4-82-001) and for 1970-1979 in National Air Pollutant Emission Estimates, 1970-1979 (EPA-450/4-81- 010). Because of modifications in methodology and use of more refined emission factors, data from this report should not be compared with data in these earlier reports.

Reporting of emissions on a nationwide basis, while useful as a general indicator of pollutant levels, has definite limitations. National totals or averages are not the best guide for estimating trends for particular localities. Yet, it is important that some criteria be established for measurement of national progress in the control of air pollutant emissions. The emission estimates presented herein represent calculated estimates based on standard emission inventory procedures. Since these data are estimates only and do not represent the results of any program for the measurement of actual emissions, their accuracy is somewhat limited. Similarly, it would not necessarily be expected that these emission estimates would be in agreement with emission estimates derived through a different emission inventory procedure. The principal objective of compiling these data is to identify probable overall changes in emissions on a national scale. It should be recognized that these estimated national trends in emissions may not be representative of local trends in emissions or air quality.

The emission estimates presented in this report are based on the most currently available EPA air pollutant emission factors and published data for fuel consumption, industrial production and other indicators of source activity levels. Published data for 1970-1980 were available in final form. In many instances, 1981 data were available only as preliminary estimates when this report was prepared. As a result, 1981 emission estimates presented in this report should be regarded as preliminary estimates to be revised in a future edition of this report.

TABLE 1
SUMMARY OF NATIONAL EMISSION ESTIMATES

Units of Measurement	Year	Particulate Matter (PM)	Sulfur Oxides (SOx)	Nitrogen Oxides (NOx)	Volatile Organics (VOC)	Carbon Monoxide (CO)
Teragrams/Year (10^6 metric tons/year)	1970	17.9	28.4	17.6	27.2	112.8
	1971	16.8	26.9	18.0	26.3	112.4
	1972	15.4	27.6	19.1	26.7	111.7
	1973	14.4	28.9	19.4	26.3	108.9
	1974	12.6	27.1	19.0	24.7	103.8
	1975	10.6	25.6	18.6	23.2	100.2
	1976	10.0	26.4	19.8	24.2	104.8
	1977	9.2	26.0	20.3	24.4	102.5
	1978	9.3	24.7	20.5	25.0	101.7
	1979	9.1	24.5	20.5	24.4	98.2
	1980	8.7	23.4	19.8	23.0	95.0
	1981	8.5	22.5	19.5	21.3	90.5
10^6 short tons/year	1970	19.7	31.3	19.4	30.0	124.3
	1971	18.5	29.7	19.8	29.0	123.9
	1972	17.0	30.4	21.1	29.4	123.1
	1973	15.9	31.9	21.4	29.0	120.0
	1974	13.9	29.9	20.9	27.2	114.4
	1975	11.7	28.2	20.5	25.6	110.4
	1976	11.0	29.1	21.8	26.7	115.5
	1977	10.1	28.7	22.4	26.9	113.0
	1978	10.2	27.2	22.6	27.6	112.1
	1979	10.0	27.0	22.6	26.9	108.2
	1980	9.6	25.8	21.8	25.4	104.7
	1981	9.4	24.8	21.5	23.5	99.8
Change 1970-1981		-53%	-21%	+11%	-22%	-20%

Note: All 1981 emission estimates presented in this report are preliminary estimates, to be updated and revised in the next edition of this report.

2. NATIONWIDE EMISSION TRENDS, 1970-1981

Table 1 gives a summary of total national emission estimates for 1970-1981. Tables 2 through 6 present summaries for each year according to the five major categories of sources: transportation, stationary source fuel combustion, industrial processes, solid waste disposal, and miscellaneous sources. More detailed breakdowns of emissions are given in Tables 7 through 9 for highway vehicles, Tables 10 through 12 for stationary source fuel combustion, and in Tables 13 through 17 for industrial processes.

In the industrial process tables the Standard Industrial Classification (SIC) in which the process is included is shown. These designations are not intended to represent the complete emissions for all SIC categories and serve only to identify and classify the industrial process shown.

In all tables data are reported in metric units, either as teragrams (10^{12} grams) or gigagrams (10^{9} grams) per year. One teragram equals approximately 1.1×10^{6} short tons and one gigagram equals approximately 1.1×10^{3} short tons.

2.1 Particulates

Particulate emissions result primarily from industrial processes and from fuel combustion in stationary sources. Since 1970, emissions from these sources have been reduced substantially by the installation of air pollution control equipment. In addition, particulate emissions decreased because of less burning of solid waste.

2.2 Sulfur Oxides

Sulfur oxide emissions occur largely from fuel combustion in stationary sources, with electric utilities being the largest individual source sector. From 1970 through 1976 electric utility emissions generally increased as the result of increased burning of fossil fuels to meet growing demands for electricity. Since 1976, electric utility emissions have decreased slightly, reflecting the installation of flue gas desulfurization controls at coal-fired electric generating stations and a reduction in the average sulfur content of fuels consumed. Emissions from other stationary source fuel combustion sectors also declined, mainly due to decreased combustion of coal by these consumers. Sulfur oxide emissions from industrial processes are also significant. Emissions from industrial processes have declined, primarily as the result of controls implemented to reduce emissions from nonferrous smelters and sulfuric acid manufacturing plants.

2.3 Nitrogen Oxides

Emissions of nitrogen oxides are produced almost entirely from fuel combustion by stationary sources and transportation sources. Emissions from transportation sources increased through 1978 as the result of increased motor vehicle travel. Since then, emissions have declined slightly as the result of Federal motor vehicle controls and the lack of significant additional growth in vehicle-miles of travel. Overall emissions from stationary source fuel combustion have increased slightly. Electric utility emissions have increased, reflecting increased use of fossil fuels, while industrial emissions decreased slightly as the result of a drop in fuel combustion by industrial sources. Emissions from residential and commercial/institutional sources have remained about the same.

2.4 Volatile Organic Compounds (VOC)

VOC emissions have decreased primarily due to the Federal motor vehicle control program for highway vehicles. In addition, emissions from solid waste disposal decreased due to less burning of solid waste and miscellaneous source emissions also decreased due to the substitution of water-based emulsified asphalt paving materials for those liquefied with petroleum distillates. Industrial process emissions have fluctuated according to economic conditions. Generally, industrial process emissions have increased, partially offsetting emission reductions in other source categories. However, due to the poor economic conditions prevalent in 1980 and 1981, process emissions have declined to a level comparable to 1970 emissions.

2.5 Carbon Monoxide

Carbon monoxide emissions occur largely from transportation sources. Emissions from highway vehicles peaked in 1972 and have declined subsequently due to the Federal motor vehicle control program. Industrial process emissions have also declined, mainly in the carbon black (obsolescence of the channel process), petroleum refining (increased use of CO boilers on catalytic cracking unit catalyst regenerators) and iron and steel (decreased production levels and increased air pollution control) industries. Emissions from the burning of solid waste and agricultural refuse have also declined substantially.

TABLE 2

NATIONAL ESTIMATES OF PARTICULATE EMISSIONS

TERAGRAMS/YEAR

SOURCE CATEGORY	1970	1972	1974	1975	1976	1977	1978	1979	1980	1981
Transportation										
Highway vehicles	0.9	1.0	1.1	1.0	1.1	1.1	1.2	1.1	1.1	1.1
Aircraft	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Railroads	0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Vessels	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other off-highway vehicles	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Transportation Total	1.2	1.3	1.3	1.3	1.4	1.4	1.5	1.4	1.4	1.4
Stationary Source Fuel Combustion										
Electric Utilities	2.3	1.9	1.7	1.5	1.3	1.2	1.2	1.0	1.0	1.0
Industrial	1.6	0.9	0.7	0.6	0.5	0.5	0.4	0.5	0.4	0.4
Commercial-Institutional	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Residential	0.4	0.3	0.3	0.3	0.4	0.4	0.5	0.6	0.6	0.6
Fuel Combustion Total	4.4	3.2	2.8	2.5	2.3	2.2	2.2	2.2	2.1	2.1
Industrial processes	10.1	9.3	6.9	5.5	4.9	4.4	4.4	4.2	3.7	3.7
Solid waste disposal										
Incineration	0.4	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2
Open burning	0.7	0.4	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2
Solid Waste Total	1.1	0.7	0.6	0.6	0.4	0.4	0.4	0.4	0.4	0.4
Miscellaneous										
Forest fires	0.7	0.7	0.8	0.6	0.9	0.7	0.7	0.8	1.0	0.8
Other Burning	0.4	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Misc. Organic Solvent	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Miscellaneous Total	1.1	0.9	1.0	0.7	1.0	0.8	0.8	0.9	1.1	0.9
Total	17.9	15.4	12.6	10.6	10.0	9.2	9.3	9.1	8.7	8.5

TABLE 3

NATIONAL ESTIMATES OF SULFUR OXIDE EMISSIONS

TERAGRAMS/YEAR

SOURCE CATEGORY	1970	1972	1974	1975	1976	1977	1978	1979	1980	1981
Transportation										
Highway Vehicles	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4
Aircraft	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Railroads	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Vessels	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.2
Other Off-highway Vehicles	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Transportation Total	0.6	0.6	0.6	0.6	0.8	0.8	0.8	0.9	0.9	0.8
Stationary Source Fuel Combustion										
Electric Utilities	15.8	15.8	16.6	16.5	17.1	16.9	15.9	15.8	15.5	14.8
Industrial	4.1	3.5	3.1	2.7	2.7	2.8	2.7	2.7	2.4	2.3
Commercial-Institutional	0.9	0.9	0.8	0.7	0.8	0.8	0.8	0.6	0.7	0.5
Residential	0.5	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2
Fuel Combustion Total	21.3	20.5	20.8	20.2	20.9	20.8	19.7	19.3	18.8	17.8
Industrial Processes	6.4	6.4	5.7	4.8	4.7	4.4	4.2	4.3	3.7	3.9
Solid Waste Disposal										
Incineration	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Open Burning	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Solid Waste Total	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Miscellaneous										
Forest Fires	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Burning	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Miscellaneous Organic Solvent	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Miscellaneous Total	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	28.4	27.6	27.1	25.6	26.4	26.0	24.7	24.5	23.4	22.5

TABLE 4

NATIONAL ESTIMATES OF NITROGEN OXIDE EMISSIONS

TERAGRAMS/YEAR

SOURCE CATEGORY	1970	1972	1974	1975	1976	1977	1978	1979	1980	1981
Transportation										
Highway Vehicles	5.5	6.5	6.5	6.6	6.9	7.0	7.1	6.8	6.7	6.6
Aircraft	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Railroads	0.6	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.7
Vessels	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.1	0.2
Other Off-highway Vehicles	0.8	0.9	0.9	0.9	1.0	1.0	1.1	1.1	1.0	0.9
Transportation Total	7.1	8.3	8.3	8.4	8.8	8.9	9.2	9.0	8.7	8.5
Stationary Source Fuel Combustion										
Electric Utilities	4.5	5.0	5.3	5.2	5.6	6.0	5.9	6.2	6.4	6.6
Industrial	3.9	3.9	3.7	3.4	3.7	3.7	3.7	3.6	3.0	2.9
Commercial-Insitutional	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2
Residential	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Fuel Combustion Total	9.1	9.6	9.7	9.3	10.0	10.4	10.3	10.5	10.1	10.1
Industrial Processes	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.6
Solid Waste Disposal										
Incineration	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Open Burning	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Solid Waste Total	0.4	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Miscellaneous										
Forest Fires	0.2	0.2	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.2
Other Burning	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Misc. Organic Solvent	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Miscellaneous Total	0.3	0.3	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.2
Total	17.6	19.1	19.0	18.6	19.8	20.3	20.5	20.5	19.8	19.5

TABLE 5

NATIONAL ESTIMATES OF VOLATILE ORGANIC COMPOUND EMISSIONS

TERAGRAMS/YEAR

SOURCE CATEGORY	1970	1972	1974	1975	1976	1977	1978	1979	1980	1981
Transportation										
Highway Vehicles	10.5	10.3	9.0	8.8	8.8	8.5	8.3	7.5	6.8	6.3
Aircraft	0.2	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Railroads	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Vessels	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5
Other Off-highway Vehicles	0.5	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Transportation Total	11.8	11.7	10.2	10.1	10.2	9.9	9.7	8.9	8.2	7.7
Stationary Source Fuel Combustion										
Electric Utilities	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Industrial	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Commercial-Institutional	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Residential	0.5	0.4	0.4	0.5	0.5	0.6	0.6	0.7	0.8	0.8
Fuel Combustion Total	0.6	0.5	0.5	0.6	0.6	0.7	0.7	0.8	0.9	0.9
Industrial Processes	9.8	10.4	10.3	9.3	10.0	10.5	11.4	11.4	10.7	9.8
Solid Waste Disposal										
Incineration	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.3
Open Burning	1.3	0.7	0.5	0.5	0.4	0.4	0.4	0.3	0.3	0.3
Solid Waste Total	1.8	1.1	0.9	0.9	0.8	0.8	0.8	0.7	0.6	0.6
Miscellaneous										
Forest Fires	0.7	0.7	0.7	0.5	0.9	0.7	0.7	0.8	0.9	0.8
Other Burning	0.3	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Misc. Organic Solvent	2.2	2.1	1.9	1.7	1.6	1.7	1.6	1.7	1.6	1.4
Miscellaneous Total	3.2	3.0	2.8	2.3	2.6	2.5	2.4	2.6	2.6	2.3
Total	27.2	26.7	24.7	23.2	24.2	24.4	25.0	24.4	23.0	21.3

TABLE 6

NATIONAL ESTIMATES OF CARBON MONOXIDE EMISSIONS

TERAGRAMS/YEAR

SOURCE CATEGORY	1970	1972	1974	1975	1976	1977	1978	1979	1980	1981
Transportation										
Highway Vehicles	77.2	80.0	73.8	73.8	75.7	74.6	73.6	69.4	65.3	62.3
Aircraft	0.9	0.9	0.9	0.9	0.9	0.9	1.0	1.0	1.0	1.0
Railroads	0.3	0.3	0.3	0.2	0.3	0.3	0.3	0.3	0.3	0.3
Vessels	1.2	1.3	1.4	1.4	1.5	1.5	1.6	1.5	1.5	1.5
Other Off-highway Vehicles	6.8	6.4	5.7	5.4	5.3	5.1	4.9	4.6	4.7	4.4
Transporation Total	86.4	88.9	82.1	81.7	83.7	82.4	81.4	76.8	72.8	69.5
Stationary Source Fuel Combustion										
Electric Utilities	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Industrial	0.7	0.7	0.7	0.6	0.7	0.7	0.7	0.7	0.6	0.6
Commercial-Institutional	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Residential	3.0	2.7	2.6	2.8	3.2	3.5	4.0	4.7	5.2	5.3
Fuel Combustion Total	4.0	3.8	3.7	3.8	4.3	4.6	5.1	5.8	6.2	6.3
Industrial Processes	9.0	8.4	8.1	6.8	7.0	7.1	7.0	6.8	6.2	6.2
Solid Waste Disposal										
Incineration	2.7	2.2	1.9	1.8	1.5	1.5	1.4	1.3	1.2	1.2
Open Burning	3.7	2.1	1.5	1.3	1.2	1.1	1.1	1.0	1.0	0.9
Solid Waste Total	6.4	4.3	3.4	3.1	2.7	2.6	2.5	2.3	2.2	2.1
Miscellaneous										
Forest Fires	5.1	5.2	5.6	4.0	6.4	5.1	5.0	5.8	6.9	5.7
Other Burning	1.9	1.1	0.9	0.8	0.7	0.7	0.7	0.7	0.7	0.7
Misc. Organic Solvent	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Miscellaneous Total	7.0	6.3	6.5	4.8	7.1	5.8	5.7	6.5	7.6	6.4
Total	112.8	111.7	103.8	100.2	104.8	102.5	101.7	98.2	95.0	90.5

TABLE 7

NITROGEN OXIDE EMISSIONS FROM HIGHWAY VEHICLES

GIGAGRAMS/YEAR

SOURCE CATEGORY	1970	1972	1974	1975	1976	1977	1978	1979	1980	1981
Gasoline-powered Vehicles										
Passenger cars	3,460	4,020	3,920	3,930	3,980	3,950	3,880	3,550	3,290	3,160
Light Duty Trucks-1	410	540	520	500	540	550	540	530	530	510
Light Duty Trucks-2	170	220	250	260	230	380	440	460	450	430
Heavy Duty Trucks	510	570	560	550	580	570	570	540	540	510
Motorcycles	3	4	6	6	6	6	6	10	10	10
Diesel-powered Vehicles										
Passenger Cars	0	0	0	1	1	2	4	10	20	30
Light Duty Trucks	0	0	0	0	0	0	0	2	5	8
Heavy Duty Trucks	940	1,180	1,290	1,300	1,430	1,520	1,610	1,720	1,920	1,970
Total	5,500	6,530	6,550	6,550	6,870	6,980	7,050	6,820	6,760	6,630

Note: One gigagram equals 10^9 grams or 10^3 metric tons (1.1×10^3 short tons). Total may differ slightly from sum of source category totals due to independent rounding of data.

TABLE 8
VOLATILE ORGANIC COMPOUND EMISSIONS FROM HIGHWAY VEHICLES

GIGAGRAMS/YEAR

SOURCE CATEGORY	1970	1972	1974	1975	1976	1977	1978	1979	1980	1981
Gasoline-powered Vehicles										
Passenger Cars	8,120	7,720	6,650	6,480	6,290	6,010	5,750	5,060	4,520	4,170
Light Duty Trucks-1	910	990	850	810	850	820	770	710	660	620
Light Duty Trucks-2	350	380	380	390	490	550	630	640	570	540
Heavy Duty Trucks	950	930	770	730	780	750	720	690	660	610
Motorcycles	90	160	210	210	210	210	210	170	130	120
Diesel-powered Vehicles										
Passenger Cars	0	0	0	0	0	0	1	5	6	9
Light Duty Trucks	0	0	0	0	0	0	0	1	2	4
Heavy Duty Trucks	110	140	140	140	160	170	180	200	220	230
Total	10,530	10,320	9,000	8,760	8,780	8,510	8,260	7,480	6,770	6,300

Note: One gigagram equals 10^9 grams or 10^3 metric tons (1.1×10^3 short tons). Total may differ slightly from sum of source category totals due to independent rounding of data.

TABLE 9

CARBON MONOXIDE EMISSIONS FROM HIGHWAY VEHICLES

GIGAGRAMS/YEAR

SOURCE CATEGORY	1970	1972	1974	1975	1976	1977	1978	1979	1980	1981
Gasoline-powered Vehicles										
Passenger cars	59,030	59,620	54,560	54,520	53,940	52,510	51,200	47,100	43,710	41,570
Light Duty Trucks-1	5,930	6,780	6,400	6,240	6,840	6,730	6,430	6,200	5,860	5,660
Light Duty Trucks-2	2,080	2,390	2,480	2,640	3,400	3,960	4,550	4,790	4,420	4,300
Heavy Duty Trucks	9,530	10,260	9,320	9,290	10,340	10,290	10,230	10,190	10,170	9,650
Motorcycles	290	490	650	650	650	660	670	570	430	390
Diesel-powered Vehicles										
Passenger Cars	0	0	0	0	1	1	3	9	10	20
Light Duty Trucks	0	0	0	0	0	0	0	2	4	7
Heavy Duty Trucks	340	420	420	420	470	500	530	570	660	680
Total	77,200	79,960	73,830	73,760	75,650	74,650	73,610	69,430	65,260	62,280

Note: One gigagram equals 10^9 grams or 10^3 metric tons (1.1×10^3 short tons). Total may differ slightly from sum of source category totals due to independent rounding of data.

TABLE 10

PARTICULATE EMISSIONS FROM FUEL COMBUSTION IN STATIONARY SOURCES

(GIGAGRAMS/YEAR)

SOURCE CATEGORY	1970	1972	1974	1975	1976	1977	1978	1979	1980	1981
Coal										
Electric Utilities	2,220	1,750	1,560	1,420	1,150	1,060	1,050	860	900	910
Industrial	1,290	650	440	350	240	230	220	260	250	250
Residential/Commercial	120	90	80	60	60	50	50	40	40	40
Coal Total	3,630	2,490	2,080	1,830	1,450	1,340	1,320	1,160	1,190	1,200
Fuel Oil										
Electric Utilities	110	120	130	120	120	140	140	120	110	90
Industrial	80	80	80	60	80	90	80	70	60	50
Residential/Commerical	70	70	60	60	60	60	60	50	50	40
Fuel Oil Total	260	270	270	240	260	290	280	240	220	180
Natural Gas										
Electric Utilities	6	6	5	5	5	5	5	5	5	6
Industrial	20	20	20	20	20	20	20	20	20	20
Residential/Commercial	10	10	10	10	10	10	10	10	10	10
Natural Gas Total	36	36	35	35	35	35	35	35	35	36
Wood										
Industrial	140	140	130	90	90	100	100	80	60	50
Residential	280	270	260	300	340	380	440	510	580	580
Wood Total	420	410	390	390	430	480	540	590	640	630
Other Fuels										
Industrial	40	40	30	40	40	30	30	30	30	30
Residential	4	4	3	3	3	3	3	3	2	2
Other Fuels Total	44	44	33	43	43	33	33	33	32	32
Fuel Combustion Total	4,390	3,250	2,810	2,540	2,220	2,180	2,210	2,060	2,120	2,080

Note: One gigagram equals 10^9 or 10^3 metric tons (1.1×10^{10} short tons). Total may differ slightly from sum of source category totals due to independent rounding of data.

TABLE 11

SULFUR OXIDE EMISSIONS FROM FUEL COMBUSTION IN STATIONARY SOURCES

(GIGARAMS/YEAR)

SOURCE CATEGORY	1970	1972	1974	1975	1976	1977	1978	1979	1980	1981
Coal										
Electric Utilities	14,330	14,410	15,110	15,170	15,690	15,230	14,210	14,350	14,210	13,660
Industrial	2,840	2,180	1,800	1,700	1,490	1,450	1,510	1,620	1,390	1,470
Residential/Commercial	350	230	240	210	200	200	230	190	140	150
Coal Total	17,520	16,820	17,150	17,080	17,380	16,880	15,950	16,160	15,740	15,280
Fuel Oil										
Electric Utilities	1,460	1,390	1,520	1,370	1,440	1,630	1,680	1,450	1,310	1,130
Industrial	1,140	1,170	1,110	880	1,090	1,210	1,100	910	850	680
Residential/Commercial	1,000	990	860	760	870	850	780	640	720	560
Fuel Oil Total	3,600	3,550	3,490	3,010	3,400	3,690	3,560	3,000	2,880	2,370
Natural Gas										
Electric Utilities	1	1	1	1	1	1	1	1	1	1
Industrial	2	2	2	2	2	2	2	2	2	2
Residential/Commercial	2	2	2	2	2	2	2	2	2	2
Natural Gas Total	5	5	5	5	5	5	5	5	5	5
Wood										
Industrial	3	3	3	3	4	4	4	4	4	4
Residential	5	4	4	5	6	6	7	8	10	10
Wood Total	8	7	7	8	10	10	11	12	14	14
Other Fuel										
Industrial	160	140	160	100	140	110	130	130	120	105
Residential	20	10	10	10	10	10	10	9	6	5
Other Fuels Total	180	150	170	110	150	120	140	139	126	110
Fuel Combustion Total	21,300	20,530	20,810	20,210	20,940	20,700	19,660	19,310	18,750	17,780

Note: One gigagram equals 10^9 grams or 10^3 metric tons (1.1×10^3 short tons). Total may differ slightly from sum of source category totals due to independent rounding of data.

TABLE 12

NITROGEN OXIDE EMISSIONS FROM FUEL COMBUSTION IN STATIONARY SOURCES

GIGAGRAMS/YEAR

SOURCE CATEGORY	1970	1972	1974	1975	1976	1977	1978	1979	1980	1981
Coal										
Electric Utilities	3,170	3,410	3,780	3,880	4,270	4,550	4,470	4,820	5,160	5,370
Industrial	700	560	480	470	440	420	430	460	400	440
Residential/Commercial	40	40	40	40	40	40	40	30	20	20
Coal Total	3,910	4,010	4,300	4,390	4,750	5,010	4,940	5,310	5,580	5,830
Fuel Oil										
Electric Utilities	390	600	670	600	620	730	680	570	440	380
Industrial	300	320	310	270	340	360	350	260	220	190
Residential/Commercial	300	300	280	260	290	280	280	230	220	180
Fuel Oil Total	990	1,220	1,260	1,130	1,250	1,370	1,310	1,060	880	750
Natural Gas										
Electric Utilities	940	960	830	740	710	730	720	790	830	820
Industrial	2,770	2,900	2,820	2,570	2,800	2,810	2,790	2,710	2,240	2,150
Residential/Commercial	330	350	330	340	350	330	340	350	330	330
Natural Gas Total	4,040	4,210	3,980	3,650	3,860	3,870	3,850	3,850	3,400	3,300
Wood										
Industrial	40	50	50	40	50	50	60	60	60	60
Residential	40	30	30	40	40	50	50	60	70	70
Wood Total	80	80	80	80	90	100	110	120	130	130
Other Fuels										
Industrial	50	50	50	50	60	50	60	70	70	60
Residential	60	60	50	40	50	40	40	30	30	30
Other Fuels Total	110	110	100	90	110	90	100	100	100	90
Fuel Combustion Total	9,130	9,630	9,720	9,340	10,060	10,440	10,310	10,440	10,080	10,100

Note One gigagram equals 10^9 grams or 10^3 metric tons (1.1 x 10^3 short tons). Total may differ slightly from sum of source category totals due to independent rounding of data.

TABLE 13

PARTICULATE EMISSIONS FROM INDUSTRIAL PROCESSES

GIGAGRAMS/YEAR

SOURCE CATEGORY (SIC)	1970	1972	1974	1975	1976	1977	1978	1979	1980	1981
Cattle Feed lots (0211)	20	20	20	20	20	20	20	20	20	20
Cotton Ginning (0724)	20	30	20	20	20	30	20	20	20	30
Metallic Ore Mining (10)	580	530	530	470	440	350	390	390	350	410
Coal Mining (1211)	350	300	250	250	260	260	250	280	290	300
Crushed Stone (142)	1,220	1,090	880	690	590	510	550	520	430	380
Sand and Gravel (144)	50	50	50	40	40	50	50	50	40	40
Clays (145)	500	360	170	90	70	50	60	40	40	40
Potash/Phosphate Rock (1474,1475)	40	40	40	30	30	30	30	30	30	30
Feed and Grain Milling (204)	80	80	60	60	50	50	50	50	50	50
Lumber and Plywood (24)	80	90	80	70	80	90	90	80	70	70
Pulp Mills (261,262)	520	440	270	180	150	150	110	110	110	110
Chemicals (28)	250	210	160	130	140	140	150	150	140	140
Petroleum Refining (2911)	60	70	70	70	60	60	60	50	50	40
Asphalt Paving and Roofing (295)	560	550	500	320	230	140	140	140	110	100
Glass (321,322)	50	50	50	40	50	50	50	40	40	40
Cement (3241)	1,390	1,340	850	690	700	650	660	590	490	460
Brick and Tile (3251)	1,080	1,180	500	400	260	270	300	260	230	180
Concrete, Lime, Gypsum (327)	540	410	340	280	230	180	180	160	150	140
Clay Sintering (3295)	90	90	70	40	20	20	10	10	10	10
Iron and Steel (3312)	1,250	1,050	840	630	550	490	500	440	370	360
Ferroalloys (3313)	160	150	150	90	80	70	60	40	30	30
Iron and Steel Foundries (332)	170	160	120	80	80	70	70	60	50	50
Primary Nonferrous Smelters (333)	320	280	200	170	140	100	100	90	90	90
Secondary Nonferrous Smelters (334,336)	50	50	50	50	50	40	40	50	50	50
Grain Elevators (4421,5153)	670	730	570	590	550	500	500	550	440	500
Total	10,100	9,350	6,850	5,500	4,890	4,360	4,440	4,220	3,700	3,670

Note: One gigagram equals 10^9 grams or 10^3 metric tons (1.1×10^3 short tons). Total may differ slightly from sum of source category totals due to independent rounding of data.

TABLE 14

SULFUR OXIDE EMISSIONS FROM INDUSTRIAL PROCESSES

GIGAGRAMS/YEAR

SOURCE CATEGORY	1970	1972	1974	1975	1976	1977	1978	1979	1980	1981
Natural Gas Production (1311)	100	120	160	160	130	120	130	140	140	160
Pulp Mills (261,262)	110	110	110	100	110	100	100	100	110	110
Sulfuric Acid (2819)	540	570	440	330	250	260	260	250	250	220
Carbon Black(2895)	0	10	10	10	10	10	10	10	10	10
Petroluem Refining (2911)	700	790	850	830	850	890	900	880	840	780
Glass(321,322)	20	20	30	30	30	30	30	30	30	30
Cement(3241)	560	590	580	500	540	620	670	670	610	590
Lime(3274)	30	30	30	30	30	30	30	30	30	30
Iron and Steel (3312)	480	440	460	480	450	450	430	440	390	410
Primary Copper (3331)	3,360	3,310	2,720	2,150	2,050	1,670	1,450	1,540	1,060	1,420
Primary Lead and Zinc (3332, 3333)	410	310	160	110	110	90	100	120	70	70
Primary Aluminum(3334)	70	70	80	60	70	80	80	80	90	80
Secondary Lead (3341)	20	20	20	20	30	30	30	40	30	30
Total	6,400	6,390	5,650	4,810	4,660	4,380	4,230	4,330	3,660	3,940

Note: One gigagram equals 10^9 grams or 10^3 metric tons (1.1×10^3 short tons). Total may differ slightly from sum of source category totals due to independent rounding of data.

TABLE 15

NITROGEN OXIDE EMISSIONS FROM INDUSTRIAL PROCESSES

GIGAGRAM/YEAR

SOURCE CATEGORY	1970	1972	1974	1975	1976	1977	1978	1979	1980	1981
Pulp Mills(261,262)	20	30	30	20	30	30	30	30	30	30
Organic Chemicals(286)	60	60	60	60	50	50	50	60	40	40
Ammonia(2873)	40	40	40	40	40	50	40	50	50	50
Nitric Acid(2873)	150	140	130	110	110	110	100	100	100	90
Petroleum Refining (2911)	220	230	240	240	240	260	260	250	240	210
Glass(321,322)	40	50	50	50	50	60	60	60	50	50
Cement(3241)	90	100	100	80	90	90	100	100	90	80
Iron and Steel(3312)	70	70	80	70	70	70	80	70	60	60
Total	690	720	730	670	680	720	720	720	660	610

Note: One gigagram equals 10^9 grams or 10^3 metric tons (1.1×10^3 short tons). Total may differ slightly from sum of source category totals due to independent rounding of data.

TABLE 16

VOLATILE ORGANIC COMPOUND EMISSIONS FROM INDUSTRIAL PROCESSES

GIGAGRAMS/YEAR

SOURCE CATEGORY	1970	1972	1974	1975	1976	1977	1978	1979	1980	1981
Crude Oil Production, Storage, and Transfer(1311,4463)	550	560	580	530	530	550	570	570	560	540
Food and Beverages(20)	120	120	130	130	130	140	140	150	150	150
Textiles(22)	180	180	180	170	170	150	180	190	190	170
Graphic Arts(27)	280	300	280	240	270	280	330	340	330	250
Plastics(2821,3079)	400	450	460	390	450	480	560	590	550	490
Organic Chemicals(286)	570	680	770	690	810	820	820	810	710	690
Other Chemicals(28)	520	430	400	330	370	410	410	420	370	380
Petroleum Refining(2911)	720	790	850	880	890	940	970	970	970	950
Rubber Tires(3011)	100	110	110	90	90	120	110	100	80	90
Glass(321,322)	50	50	50	50	60	60	70	60	60	60
Iron and Steel(3312)	110	100	100	90	100	90	80	90	80	70
Petroleum Product Storage and Transfer(5171,5541)	1,570	1,720	1,730	1,740	1,780	1,780	1,810	1,660	1,500	1,460
Dry Cleaning(721)	280	300	280	250	260	270	320	330	320	240
Adhesives	460	490	460	400	440	460	550	560	540	420
Degreasing	560	500	470	400	420	420	460	460	440	350
Solvent Extraction Processes	230	240	220	190	200	220	260	260	250	200
Surface Coating	1,730	1,880	1,780	1,470	1,650	1,810	2,200	2,230	2,070	1,800
Other Organic Solvent Use	1,370	1,480	1,470	1,210	1,380	1,460	1,530	1,620	1,560	1,460
Total	9,790	10,380	10,300	9,250	10,000	10,500	11,370	11,400	10,730	9,770

[1]This is a general category which includes process emissions from organic solvent use in a wide variety of industries. Thus no specific SIC is given.

Note: One gigagram equals 10^9 grams or 10^3 metric tons (1.1×10^3 short tons). Total may differ slightly from sum of source category totals due to independent rounding of data.

TABLE 17

CARBON MONOXIDE EMISSIONS FROM INDUSTRIAL PROCESSES

GIGAGRAMS/YEAR

SOURCE CATEGORY	1970	1972	1974	1975	1976	1977	1978	1979	1980	1981
Pulp Mills (261,262)	550	590	610	550	620	630	650	660	720	740
Inorganic Pigments(2816)	20	20	30	20	30	30	30	30	30	30
Charcoal(2861)	60	60	50	30	30	40	40	40	30	30
Organic Chemicals(286)	340	420	460	470	450	500	540	560	500	520
Ammonia(2873)	100	110	110	120	120	130	120	130	140	140
Carbon Black(2895)	2,600	1,780	1,680	1,310	1,370	1,560	1,450	1,370	1,150	1,230
Petroleum Refining(2911)	2,000	2,100	2,060	2,040	1,960	1,870	1,780	1,690	1,600	1,490
Asphalt Roofing(2952)	10	10	10	10	10	20	20	20	10	10
Iron and Steel(3312)	1,620	1,560	1,460	1,100	1,180	1,160	1,210	1,130	950	970
Iron Foundries(3321)	1,090	1,180	920	590	590	470	440	410	310	300
Primary Aluminum(3334)	590	610	730	580	630	680	720	750	760	740
Total	8,980	8,440	8,120	6,820	7,000	7,070	7,010	6,790	6,200	6,200

Note: One gigagram equals 10^9 grams or 10^3 metric tons (1.1×10^3 short tons). Total may differ slightly from sum of source category totals due to independent rounding of data.

3. METHODS

The generation of an emission inventory involves many steps to achieve the desired result, which is to estimate the amount of emissions for selected pollutants in a defined geographical area. Ideally, nationwide emission estimates should result from a summation of county, state, and regional data in which each component is reported separately. The National Emissions Data System (NEDS) uses this procedure. The methods used to prepare data for this publication are as similar as possible to those used for NEDS data preparation. Since NEDS uses a more detailed procedure involving calculation of emissions for individual sources and summation of these individual emission totals to produce national totals, there is a much greater chance for errors or omissions to occur in the NEDS data. Because of the basic similarity of techniques, discrepancies between national totals reported herein and those given in NEDS reports are due largely to incomplete data reporting and errors in the NEDS data. The quality of NEDS data over/time has improved so that the differences between NEDS emission reports for 1977 and later years and national emission totals determined by the procedure used for this publication are not as great as in earlier NEDS reports. Moreover, historical NEDS data are not revised to account for updated emission factors, errors or omissions in the data. As a result annual NEDS publications do not necessarily represent a consistent trend in estimated emissions.

Because it is impossible to test every pollutant source individually, particularly area sources, an estimating procedure must be used. In order to do this, however, one must either estimate the emissions directly or estimate the magnitude of other variables that can then be related to emissions. These indicators include fuel consumption, vehicle miles, population, sales, tons of refuse burned, raw materials processed, etc., which are then multiplied by appropriate emission factors to obtain emission estimates.

The limitations and applicability of emission factors must be understood. In general, emission factors are not precise indicators of emissions from a single source; rather, they are quantitative estimates of the average rate of pollutant released as a result of some activity. They are most valid when applied to a large number of sources and processes. If their limitations are recognized, emission factors are extremely useful in determining emission levels. A detailed discussion of emission factors and related information is contained in Reference 2. The emission factor thus relates quantity of pollutants emitted to indicators such as those noted above, and is a practical approach for determining estimates of emissions from various source categories.

A discussion of trends is meaningful only when there is a common basis for evaluation. It was necessary, therefore, to quantify emissions using the same criteria for each year. This meant using the same estimation techniques, using equal or equivalent data sources, covering the same pollutant sources, and using compatible estimates of pollutant control levels from year to year. Estimates for previous years were updated using current emission factors and including the most recent information available. The criteria used in calculating emissions was the same for all years.

The methodology used in generation of emission estimates for individual source categories follows.

3.1 Transportation

3.1.1 Motor Vehicles

Emission estimates from gasoline-and diesel-powered motor vehicles were based upon vehicle-mile tabulations and emission factors. Eight vehicle categories are considered; light duty gasoline (mostly passenger cars), light duty diesel passenger cars, light duty gasoline trucks (trucks less than 6000 pounds in weight), light duty gasoline trucks 6000 to 8500 pounds in weight, light duty diesel trucks, heavy duty gasoline trucks and buses, and heavy duty diesel trucks and buses, and motorcycles. The emission factors used are based on the latest available data from Reference 3. The MOBILE 2 model, developed by the EPA Office of Mobile Source Air Pollution Control was used to calculate emission factors for each year. The emission factors are weighted to consider the approximate amount of motor vehicle travel in low altitude areas, high altitude areas, and California to obtain overall national average emission factors. For each area a representative average annual temperature, together with national averages for motor vehicle model year distributions and hot/cold start vehicle operation percentages were used to calculate the emission factors. Average speed is taken into account according to the published distribution of vehicle-miles travelled (VMT) for urban and rural roadways. These data are published in Reference 4. For rural VMT, the average speed is considered to be 45 miles per hour, and for urban VMT, 19.6 miles per hour.

3.1.2 Aircraft

Aircraft emissions are based on emission factors and aircraft activity statistics reported by the Federal Aviation Administration.[5] Emissions are based on the number of landing-takeoff (LTO) cycles. Any emissions in cruise mode, which is defined to be above 3000 feet (1000 meters) are ignored. Average emission factors for each year, which take into account the national mix of aircraft types for general aviation, military, and commercial aircraft, are used to compute the emissions.

3.1.3 Railroads

The Department of Energy reports consumption of diesel fuel and residual fuel oil by railroads.[6] Average emission factors applicable to diesel fuel consumption were used to calculate emissions. The average sulfur content of each fuel was used to estimate SO_x emissions. Coal consumption by railroads was obtained from References 7 and 13.

3.1.4 Vessels

Vessel use of diesel fuel, residual oil, and coal is reported by the Department of Energy.[6,7] Gasoline use is based on national boat and motor registrations, coupled with a use factor (gallons/motor/year) from Reference 8. Emission factors from AP-42[2] are used to compute emissions. Since AP-42 does not contain an emission factor for coal use by vessels, an average emission factor for coal combustion in boilers was used.

3.1.5 Nonhighway Use of Motor Fuels

Gasoline and diesel fuel are consumed by off-highway vehicles. The fuel use is divided into seven categories; farm tractors, other farm machinery, construction equipment, industrial machinery, small general utility engines such as lawnmowers and snowthrowers, snowmobiles, and motorcycles. Fuel use is estimated for each category from estimated equipment population and an annual use factor of gallons per unit per year.[8]

3.2 Fuel Combustion in Stationary Sources

3.2.1 Coal

Bituminous coal, lignite, and anthracite coal use are reported by the Department of Energy.[7,11] Most coal is consumed by electric utilities. Average emission factors and the sulfur content of each type of coal were used to estimate emissions. Degree of particulate control was based on a report by Midwest Research Institute[9] together with data from NEDS[10]. Sulfur content data for electric utilities are available from the Department of Energy[11]. Sulfur contents for other categories are based on coal shipments data reported in Reference 7 and average sulfur contents of coal shipped from each production district as reported in Reference 13 or 24. For electric utilities, SO_2 emissions are adjusted to account for flue gas desulfurization controls, based on data reported in Reference 11.

3.2.2 Fuel Oil

Distillate oil, residual oil, and kerosene are consumed by stationary sources nationwide. Consumption by user category is reported by the Department of Energy.[6] Average emission factors and the sulfur content of each fuel were used to estimate emissions.

3.2.3 Natural Gas

Natural gas consumption data are also reported by the Department of Energy.[12] Average emission factors from AP-42[2] were used to calculate the emission estimates.

3.2.4 Other Fuels

Consumption of wood has been estimated by the Department of Energy.[27] Consumption of bagasse is based on data reported in NEDS.[10] Sales of liquefied petroleum gas (LPG) are reported in Reference 25. Estimated consumption of coke and coke-oven gas are based on References 13 and 26, together with data from NEDS. Average emission factors were used to calculate emissions.

3.3 Industrial Processes

In addition to fuel combustion, certain other industrial processes generate and emit varying quantities of pollutants into the air. The lack of published national data on production, type of equipment, and controls, as well as an absence of emission factors, makes it impossible to include estimates of emissions from all industrial process sources.

Production data for industries that produce the great majority of emissions were derived from literature data. Generally, the Minerals Yearbook,[13] published by the Bureau of Mines, and Current Industrial Reports,[14] published by the Bureau of the Census, provide adequate data for most industries. Average emission factors were applied to production data to obtain emissions. Control efficiencies applicable to various processes were estimated on the basis of published reports[9] and from NEDS data.[10]

For the purposes of this report, petroleum product storage and marketing operations (gasoline, crude oil, and distillate fuel oil storage and transfer, gasoline bulk terminals and bulk plants, retail gasoline service stations) are included as industrial processes. Also included as industrial processes are industrial surface coating and degreasing operations, graphic arts (printing and publishing), and dry cleaning operations. All of these processes involve the use of organic solvents. Emissions from the consumption of organic solvents are estimated based on data reported in Reference 15. It is assumed that all solvents consumed are eventually released as air pollution.

3.4 Solid Waste Disposal

A study conducted in 1968 on solid waste collection and disposal practices[16] was the basis for estimating emissions from solid waste disposal. Results of this study indicate that the average collection rate of solid waste is about 5.5 pounds per capita per day in the United States. It has been stated that a conservative estimate of the total generation rate is 10 pounds per capita per day. The

results of this survey were updated based on data reported in NEDS and used to estimate, by disposal method, the quantities of solid waste generated. Average emission factors were applied to these totals to obtain estimates of total emissions from the disposal of solid wastes.

3.5 Miscellaneous Sources

3.5.1 Forest Fires

The Forest Service of the Department of Agriculture publishes information on the number of forest fires and the acreage burned.[17] Estimates of the amount of material burned per acre are made to estimate the total amount of material burned. Similiar estimates are made to account for managed burning of forest areas. Average emission factors were applied to the quantities of materials burned to calculate emissions.

3.5.2 Agricultural Burning

A study[18] was conducted by EPA to obtain from local agricultural and pollution control agencies estimates of the number of acres and estimated quantity of material burned per acre in agricultural burning operations. These data have been updated and used to estimate agricultural burning emissions, based on average emission factors.

3.5.3 Coal Refuse

Estimates of the number of burning coal-refuse piles existing in the United States are made in reports by the Bureau of Mines.[19] Their publication presents a detailed discussion of the nature, origin, and extent of this source of pollution. Rough estimates of the quantity of emissions were obtained using this information by applying average emission factors for coal combustion. It was assumed that the number of burning refuse piles decreased to a negligible amount by 1975.

3.5.4 Structural Fires

The United States Department of Commerce publishes, in their statistical abstracts, information on the number and types of structures damaged by fire[20]. Emissions were estimated by applying average emission factors for wood combustion to these totals.

3.5.5 Nonindustrial Organic Solvent Use

This category includes nonindustrial sales of surface coatings (primarily for architectural coating) solvent evaporation from consumer products (aerosols, space deodorants, polishes, toiletries, etc.), use of volatile organic compounds as general cleaning solvents, paint removers, and liquefaction of asphalt paving compounds, and other undefined end uses. Total national organic solvent use is estimated from chemical production reports of Reference 21, together with estimates of the portion of total production for use as solvent for each chemical.[15] It is assumed that all solvent production is equal to the amount necessary to make up for solvent lost through evaporation. Estimated emissions from organic solvent use by industrial processes and selected nonindustrial solvent use categories were obtained from Reference 15. Solvent use not accounted for by industrial processes is reported as nonindustrial organic solvent use, with annual estimates adjusted according to solvent production levels.

4. Analysis of Trends

National trends in air pollutant emissions are a function of a number of factors. Air pollution control measures and economic conditions have the strongest impact on total emissions. National emission trends do not provide any insight into the distribution or concentration of air pollution sources within the United States. Therefore, local emission trends do not necessarily coincide with national emission trends. Based on the national implementation of control measures for some classes of sources, such as highway motor vehicles, it is reasonable to infer that for most localities, the national trend in emissions reasonably approximates local trends in emissions for the same class of sources.

In addition to the fact that national emission trends do not measure local changes in emission densities, national emission trends may not be consistent with air quality trends because of the impact of meteorological factors on air quality data. Also, the estimates for PM, SOx, and NOx emissions include more substances than are routinely measured by ambient air monitoring equipment. For example, high-volume air samplers collect only suspended particulates approximately 0.3 to 100 micro-meters in diameter, but particulate emission inventories include both suspended and settled particulates generated by man's activities. Likewise sulfur dioxide (SO_2) and nitrogen dioxide (NO_2) ambient air monitors measure only those two compounds while oxides of sulfur (SOx) and nitrogen (NOx) are included in the emission estimates. In each case, the substance measured by the ambient air monitor is the most prevalent constituent of its pollutant class or is acknowledged to be its most representative indicator. Estimates of oxidant emissions are not provided because most oxidant species are secondary pollutants generated by photochemical reactions in the atmosphere. Emission estimates of VOC, a major ingredient in oxidant-producing reactions, were developed from current emission factors.[2,3] Generally, excluded from VOC estimates were emissions of methane, ethane, methyl chloroform, and other compounds which are considered to be of negligible photochemical reactivity. Organic species were identified based on Reference 22. If no data were available for a source category, the total nonmethane hydrocarbon or the total hydrocarbon emission factor from Reference 2 was used. Highway vehicle emissions were estimated as nonmethane VOC's.[3]

The following sections discuss the most important factors influencing the emission trends for each pollutant.

4.1 Particulates

Particulate emissions result primarily from fuel combustion in stationary sources and from industrial processes. Substantial reductions in particulate emissions have occurred because of the installation of control equipment on these sources. The extent of

TABLE 18

THEORETICAL 1981 NATIONAL EMISSION ESTIMATES
BASED ON 1970 LEVEL OF CONTROL

(TERAGRAMS/YEAR)

Source Category	PM	SOX	NOX	VOC	CO
Transportation					
Highway Vehicles	1.3	0.4	8.0	14.4	104.7
Non-Highway	0.3	0.4	1.9	1.4	7.3
Transportation Total	1.6	0.8	9.9	15.8	112.0
Stationary Source Fuel Combustion					
Electric Utilities	4.5	28.3	7.2	0.0	0.3
Industrial	1.0	2.6	2.9	0.1	0.6
Residential/Commercial	0.7	0.7	0.6	0.8	5.4
Fuel Combustion Total	6.2	31.6	10.7	0.9	6.3
Industrial Processes(SIC)					
Mining Operations (10,12,13,14)	2.8	0.3	0.0	0.0	0.0
Food and Agricultural (02,07,20)	1.3	0.0	0.0	0.2	0.0
Wood Products (24,26)	0.8	0.1	0.0	0.0	0.7
Chemicals (28)	0.3	0.8	0.3	2.0	2.7
Petroleum Refining (29)	0.1	1.0	0.2	1.1	2.1
Metals (33)	1.5	3.5	0.1	0.1	2.4
Mineral Products (32)	3.3	0.7	0.1	0.1	0.0
Miscellaneous	0.0	0.0	0.0	7.6	0.0
Industrial Processes Total	10.1	6.4	0.7	11.1	7.9
Solid Waste	1.2	0.1	0.4	2.1	7.1
Miscellaneous	0.9	0.0	0.2	3.1	6.4
Total	20.0	38.9	21.9	33.0	139.7
1981 Actual Emissions (Table 1)	8.5	22.5	19.5	21.3	90.5
Theoretical 1981 Emissions As A Percentage of 1981 Actual Emissions	235%	173%	112%	155%	154%
1970 Actual Emissions (Table 1)	17.9	28.4	17.6	27.2	112.8
Theoretical 1981 Emissions As A Percentage of 1970 Actual Emissions	112%	137%	124%	121%	124%

the reduction is most evident from the data in Table 18 which shows theoretical 1981 national emission estimates, assuming that pollutant control levels did not change since 1970. Overall, particulate emissions would have increased by about 12 percent from 1970 to 1981 with no change in the degree of control from 1970. In comparison, as shown in Table 1, particulate emissions decreased about 53 percent from 1970 to 1981. Thus, 1981 actual particulate emissions were less than half of what they might have been without additional control efforts since 1970.

A large portion of the particulate emissions from stationary source fuel combustion, result from the combustion of coal. In 1970, a larger proportion of coal was consumed in the industrial and residential sectors. Residential coal use has declined substantially since 1970, resulting in a corresponding reduction in emissions. Industrial coal use has also declined, but not to the same extent. The degree of control employed by industrial coal consumers has increased however, so that overall industrial coal combustion emissions have decreased by 1981 to only about 20 percent of the estimated 1970 level. On the other hand, coal combustion by electric utilities has increased greatly, from an estimated 321 million tons in 1970 to 597 million tons in 1981. However, particulate emissions from electric utilities have decreased, despite continued increases in coal consumption. Installation of improved control equipment is responsible for this reduction. New facilities constructed in the 1970's were required to meet New Source Performance Standards (NSPS) requirements to achieve a high degree of control. From Tables 2 and 18, it can be seen that if the 1970 level of control had remained in effect in 1981, electric utility emissions would have nearly doubled, from 2.3 teragrams to 4.5 teragrams. Estimated actual 1981 emissions from electric utilities were 1.0 teragrams, a decrease of 56 percent from 1970.

Particulate emissions from industrial processes have been reduced substantially due to installation of improved control equipment mandated by air pollution control programs. Since 1970, actual emissions from industrial processes declined by over 60 percent. If the 1970 control level had remained unchanged to 1981, emissions would have stayed about the same. It should be noted that industrial production levels for many sectors in 1981 were significantly lower than in the previous few years, reflecting poor economic conditions. This downturn in industrial production also contributes to a decreased level of emissions relative to 1970. Table 13 shows estimated emissions for specific processes. These annual emissions estimates reflect changes in production levels along with an increase in average control levels from 1970 to 1981.

Caveats that should be noted with respect to these particulate emission estimates are first that the estimates represent total particulate emissions, without any distinction of particle sizes. Thus, both large particles and small particles are included. Emissions of very large particles are more likely to settle out of the atmosphere and not be measured as total suspended particulate by air quality monitoring equipment. Small and intermediate size particles are more likely to remain airborne and are more efficiently captured by total suspended particulate air monitoring equipment. Small particles are also capable of being inhaled into the human respiratory system, posibly causing adverse health effects. The particulate emission controls that have been employed to date have been most effective in reducing emisssions of large and intermediate size particles. The trend in the emissions of small particles is not clearly known. It is very doubtful whether small particle emissions have been reduced to the extent that total particulate emissions have been reduced, however. It should be noted that some small particles may be formed in the atmosphere as the result of various chemical and physical processes. Such particles are not included in the estimated total particulate emissions. A second caveat is that fugitive particulate (emissions from unconfined sources such as storage piles, material loading, etc.) emissions are incompletely accounted for in the emission totals. Rough estimates of industrial process fugitive emissions are included for some industries. Area source fugitive dust emissions (unpaved roads, construction activities, etc.) are not included at all. Similarly, natural sources of particulates, such as wind erosion or dust, are not included. (An exception is forest fires, some of which result from natural causes). In total, these fugitive emissions may amount to a considerable portion of total particulate emissions. The controls applied to these sources have so far been minimal. Due to the lack of adequate emission factors and emission inventory techniques for these sources, fugitive particulate emissions have not been included in most emission inventories. As additional data become available, it is expected that estimates of fugitive particulate emissions will be included in future emission inventories. It should be noted, however, that a major portion of the fugitive particulate emissions are relatively large particles that are not readily captured by particulate air quality monitors. Similarly, these large particles do not effectively enter into the human respiratory system.

4.2 Sulfur oxides

Fuel combustion by stationary sources produces most sulfur oxide emissions. In addition, certain industrial processes, such as smelting of copper, lead, and zinc ores, sulfuric acid manufacturing, and other industries also produce sulfur oxide emissions. Since 1970, total sulfur oxide emissions have declined slightly as the result of use of fuels with lower average sulfur contents, some scrubbing of sulfur oxides from fluegases, and controls on industrial process sources. Significant emission reductions from industrial processes

have occurred, mostly from non-ferrous smelters and sulfuric acid plants. By-product recovery of sulfuric acid at smelters has increased since 1970. As a result sulfur oxide emissions that previously would have been released to the atmosphere are recovered as sulfuric acid. Since 1972, new sulfuric acid manufacturing plants have been subject to New Source Performance Standards requirements. These rules have contributed to decreased emissions, as new plants built to meet new product demands or replace old facilities, must meet more stringent emission limitations than old facilities.

As shown in the tables, since 1970 sulfur oxide emissions from electric utilities account for more than half of total emissions. Combustion of sulfur-bearing fuels, chiefly coal and residual fuel oil, is responsible. Between 1970 and 1981, utility use of coal increased by over 85 percent. Emissions from utilities have actually decreased slightly, because fuels with lower sulfur content have been used to the extent that they were available. In addition, flue gas desulfurization systems installed by the late 1970's have been effective in preventing additional increases in electric utility emissions. 1981 electric utility emissions would have been approximately 10 percent higher without the operation of flue gas desulfurization controls. The theoretical 1981 national emission estimates given in Table 18 for stationary fuel combustion sources are based on 1981 fuel amounts but 1970 average sulfur contents. On this basis, electric utility emissions would have increased 79 percent. In fact, emissions decreased about 6 percent. Sulfur oxide emissions from other fuel combustion sectors decreased, primarily due to less coal burning by these industrial, commercial and residential consumers.

4.3 Nitrogen oxides

Nitrogen oxide emissions result almost entirely from transportation and stationary fuel combustion sources. Controls applied to sources of NOx emissions have had a limited effect in reducing emissions through 1981. Table 18 shows that with the 1970 control level, national NOx emissions would have been only 12 percent higher than actual 1981 emissions. The emissions from stationary fuel combustion sources largely reflect the actual growth in fuel consumption. For electric utilities, NSPS control requirements have held down the growth in NOx emissions somewhat. Nevertheless, NOx emissions from electric utilities increased 47 percent from 1970 to 1981. For mobile sources, NOx emissions were controlled as a result of the Federal Motor Vehicle Control Program (FMVCP). Nitrogen oxide emissions from highway vehicles would have increased 45 percent, had there been no change in control level since 1970. The estimates of actual NOx emissions show a 20 percent increase.

4.4 Volatile organic compounds

Since 1970, emissions of VOC decreased primarily due to motor vehicle controls and less burning of solid waste. Had controls not been implemented, a substantial increase in emissions from highway

vehicles would have occurred. From 1970 to 1981, vehicle-miles of travel in the U.S. increased by about 37 percent.[4] A comparable increase in emissions would have occurred had 1970 control levels remained unchanged. As a result of the controls put in place, VOC emissions from highway vehicles actually decreased 40 percent. VOC emissions also decreased due to the substitution of water-based emulsified asphalts (used for road paving) for asphalts liquefied with petroleum distillates (cutback asphalts). This is reflected in the decreased emissions reported for miscellaneous organic solvent use.

These decreases were offset by increases in industrial process emissions so that overall, total VOC emissions were reduced only about 22 percent from 1970 to 1981. Industrial process emissions increased due to higher production levels, particularly in industrial sectors such as petroleum refining, organic chemical production, and industrial uses of organic solvents. Control procedures employed were effective in limiting the growth in emissions, however. In addition, source production levels in 1980 and 1981 were relatively low due to poor economic conditions. Through the mid-1970's, emissions from petroleum product storage and marketing operations also increased as the result of increased demand for petroleum products, particularly motor gasoline. Since 1979, emissions from this source sector are estimated to have decreased as the result of declining product demand and more effective control measures.

Volatile organic compounds along with nitrogen oxides are participants in atmospheric chemical and physical processes that result in the formation of ozone and other photochemical oxidants. Emissions of VOC that are most likely to have a role in such atmospheric processes are included in the reported emissions estimates. Photochemically non-reactive compounds such as methane are not included in the estimated emissions of VOC. Biogenic sources of organic compounds such as trees and other vegetation are not included either. Initial estimates are that emissions of VOC from naturally-occurring sources exceed the amount of anthropogenic emissions. The extent to which biogenic sources of VOC contribute to oxidant formation, if at all, has not been clearly established, however.

4.5 Carbon Monoxide

Highway motor vehicles are the largest contributing source of CO emissions. The implementation of the Federal Motor Vehicle Control Program (FMVCP) has been successful in reducing CO emissions since the early 1970's. From 1972 through 1978, motor vehicle miles of travel increased 22 percent, but because of controls on new vehicles, total CO emissions from highway vehicles decreased 8 percent. From 1978 to 1981, vehicle miles of travel are estimated to have declined about one

percent. This lack of growth in vehicle travel together with an increased degree of control because of stricter emission standards for new vehicles and the gradual disappearance of older uncontrolled vehicles from the vehicle fleet, produced an estimated 15 percent drop in highway vehicle emissions in just three years. Overall from 1970 to 1981, without the implementation of FMVCP, highway vehicle emissions would have increased 36 percent. By comparison, actual emissions are estimated to have decreased 19 percent.

CO emissions from other sources have also generally decreased. In 1970, emissions from burning of agricultural crop residues were greater than in more recent years. Solid waste disposal emissions have also decreased as the result of implementation of regulations limiting or prohibiting burning of solid waste in many areas. Emissions of CO from stationary source fuel combustion occur mainly from the residential sector. These emissions were reduced somewhat through the mid-1970's as residential consumers converted to natural gas, oil, or electric heating equipment. Recent growth in the use of residential wood stoves has reversed this trend, but increased CO emissions from residential sources continue to be insignificant compared to highway vehicle emissions. CO emissions from industrial processes have generally been declining since 1970 as the result of the obsolescence of a few high-polluting processes such as manufacture of carbon black by the channel process and installation of controls on other processes.

5. References

*1. National Emissions Report, National Emissions Data System (NEDS).NADB, OAQPS,US Environmental Protection Agency,Research Triangle Park,NC. Publication No.EPA-450/4-81-009.August 1981.

2. Compilation of Air Pollutant Emission Factors,Third Edition (Including Supplements 1-13).US Environmental Protection Agency,Research Triangle Park,NC.Publication No.AP-42.

3. Mobile 2 Users's Guide and Supporting Background Documentation (Draft) US Environmental Protection Agency, Office of Mobile Source Air Pollution Control, Ann Arbor, Michigan.1979

*4. Highway Statistics.Federal Highway Administration,US Department of Transportation,Washington,DC.1980.

*5. FAA Air Traffic Activity.Federal Aviation Administration,US Department of Transportation,Washington,DC.1981.

*6. Energy Data Reports,Deliveries of Fuel Oil and Kerosene,Energy Information Administration,US Department of Energy,Washington,DC.Publication No. DOE/EIA-0113(80).February 1982.

*7. Coal Distribution January-December, Energy Information Administration, US Department of Energy, Washington,DC.Publication No. DOE/EIA-0125(81/4Q).April 1982.

8. Exhaust Emissions from Uncontrolled Vehicles and Related Equipment Using Internal Combustion Engines.Southwest Research Institute, San Antonio,TX.Prepared for US Environmental Protection Agency, Research Triangle Park,NC.EPA Contract No.EHS 70-108.Oct 1973.

9. Particulate Pollutant Systems Study.Midwest Research Institute,Kansas City,MO.Prepared for US Environmental Protection Agency,Research Triangle Park,NC.National Air Pollution Control Administration Contract No.CPA 22-69-104.May 1971.

10. Standard Computer Retrievals from the National Emissions Data System (NEDS).Unpublished computer report available from NADB,OAQPS,US Environmental Protection Agency, Research Triangle Park,NC.

*11. Energy Data Reports, Cost and Quality of Fuels for Electric Utility Plants-1980, Energy Information Administration, US Department of Energy, Washington, D.C. Publication No. DOE/EIA-0191(80).June 1981.

*12. Natural Gas Annual,Energy Information Administration,U.S. Department of Energy,Washington,D.C. Publication No. DOE/EID-0131(80).February 1982.

13. Minerals Yearbook.Bureau of Mines, US Department of the Interior, Washington,DC.1980.

*14. Current Industrial Reports.Bureau of the Census,US Department of Commerce, Washington,DC.

15. End Uses of Solvents Containing Volatile Organic Compounds, The Research Corporation of New England, Wethersfield, CT,EPA Publication EPA-450/3-79-032, May 1979.

16. 1968 National Survey of Community Solid Waste Practices.Public Health Service,US Department of Health,Education,and Welfare,Cincinnati, OH.PHS Publication No.1867.1968.

*These publications are issued periodically. The most recent publication available when this document was prepared is cited.

*17.Wildfire Statistics.Forest Service,US Department of Agriculture, Washington,DC 1978.
18.Emissions Inventory from Forest Wildfires,Forest Managed Burns, and Agricultural Burns.US Environmental Protection Agency, Research Triangle Park,NC 27711.Publication No.EPA-450/3-74-062. November 1974.
19.Coal Refuse Fires,An Environmental Hazard.Bureau of Mines,US Department of the Interior,Washington,DC.Information Circular 8515.1971.
*20.Statistical Abstract of the United States.Bureau of the Census, US Department of Commerce,Washington,DC.1981(102nd ed.)
*21.Chemical and Engineering News,Annual Facts and Figures Issue,American Chemical Society,Washington, DC.June 14,1982.
22.Volatile Organic Compound (VOC) Species Data Manual Second Edition,US Environmental Protection Agency,Research Triangle Park,NC.Publication No.EPA-450/4-80-015.July 1980.
23.Standard Industrial Classification Manual 1972, Executive Office of the President, Office of Management and Budget, Washington, D.C.
*24.Coal Production,Energy Information Administration,US Department of Energy,Washington,DC.1979.Publication No. DOE/EIA-0118(80).May 1982
*25.Energy Data Reports,Sales of Liquefied Petroleum Gases and Ethane, Energy Information Administration,US Department of Energy,Washington, DC.Publication No. DOE/EIA-0114(80).December 1981.
*26.Coke and Coal Chemicals,Energy Information Administration,US Department of Energy,Washington,DC.Publication No. DOE/EIA-0120(80).November 1981.
27.Estimates of U.S. Wood Energy Consumption from 1949 to 1981.U.S. Dept. of Energy, Washington,DC.Publication No. DOE/EIA-0341.August 1982.

*These publications are issued periodically. The most recent publication available when this document was prepared is cited.